1 Introduction: Casting New Light on Old Stones

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The purpose of this monograph is to take a new look at various aspects of stone artefact analysis that reveal important and exciting new information about the past. This invovles reorienting our methodological approach to stone artefacts as well as the questions asked of them. The papers making up this volume tackle a number of issues that have long been at the heart of archaeology's problematic relationship with stone artefacts, including our understanding of the dynamic nature of past stoneworking practices, the utility of traditional classificatory schemes, and ways to unlock the vast amount of information about the strategic role of lithic technology that resides in stone artefact assemblages.

The dominant theme of this monograph is the pursuit of new ways of characterising the effects of manufacturing and susbsistence behaviour on stone artefact assemblages, but three central concerns are evident throughout this volume. The first centres on exploring the effects of reduction intensity on artefact form using quantitative methods for measuring reduction and changes to implement form, with implications for the way artefacts are classified and the manufacturing process depicted more generally. The second theme concerns our understanding of the important role that morphological features created during the reduction process, whether deliberately or otherwise, can have in creating opportunities and limitations for efficient tool use and continued reworking. The third and final theme explores the potential of assemblage variability to reveal valuable information about the organisation of settlement and susbsistence in Aborignial societies of the past.

All of the studies presented in this monograph incorporate measures of artefact reduction of one sort or another to understand the time-ordering of manufacutring actions, their effects on artefact morphology, and the differential investment and husbanding of tools as a result of variable use-lives, artefact transport and raw material rationing. This unifying concern for measuring the amount of shaping, resharpending and reworking an artefact has received makes this volume unique, and hopefully draws attention to this invaluable and under-utilised analytical tool as an extremely informative means of exploring past human behaviour and the determinants of assemblage variability.

The papers presented in this volume are the product of research conducted entirely within Australia, and therefore have an unavoidably atipodean flavour in terms of their theoretical outlook and methodological bent. Rather than representing parochial interests in Australian sites and assemblages, however, this volume intends to present the distincitive persepective developed 'down under' to a larger audience. We see this perspective as largely deriving from, first of all, a freedom from the hegemony of typological schemes that have always underlain lithic analysis in the northern hemisphere; secondly, access to a rich and variable ethnographic record that has allowed observation of stone artefact production and use in dynamic social and economic contexts; thirdly, a strongly held view that few recurring formal implement types of the kind found in Europe and North America were to be found in Australia until the mid-Holocene, and that no direct form-function relationships could be found to inhere for these types; and finally, that diverse spatial and chronological patterning made broad chronological or geographic phases and culture areas difficult to establish in the way they have been in other parts of the world (Clarkson 2004; Hayden 1977, 1979; Hiscock 1998; Holdaway 1995; Holdaway and Stern 2004). Hiscock (1998) and Holdaway and Stern (2004) provide interesting historical reviews of the reasons why a distinctive approach to stone artefact analysis developed the way it did in Australia.

In turn, such factors probably account for the numerous failed attempts to introduce universally employed typologies in Australia (Holdaway 1995; Holdaway and Stern 2004), as well as the frequent confounding of simple models of colonisation and the evolution of technology both here and elsewhere (Foley and Mirazon Lahr 2003; White 1977). Thus, although Australian archaeologists have of course been aware of, and influenced by, lithic studies and theoretical perspectives in other parts of the world, they have nevertheless developed their own distinctive perspective on the subject. Hopefully this volume successfully captures some of this flavour as we re-examine the empirical basis for some of the more pervasive Australian typologies, rethink form-function realtionships, and explore assemblage variation in regions where no commonly recurring retouched implement types are found. Although most papers employ Australian case-studies, the issues raised in this volume are of direct relevance to major themes being debated in international lithic studies today.

It would be a mistake however to suggest that only a single viewpoint exists in Australia, as a wide range of perspectives on the meaning and causes of assemblage variation exists, as do many different approaches to lithic analysis itself. What this volume has chosen to focus on

as a unifying theme, therefore, is the novel ways in which a consideration of artefact reduction can shed new light on old stones. To preface these studies it is important to briefly review the rationale behind our focus on analysing artefact reduction as a relevant and enlightening facet of lithic anlaysis.

Why Measure Reduction?

As stone-working is a reductive technology, measuring the degree to which this process has progressed will profitably form the basis of many kinds of lithic analysis. Quantifying the extent of reduction allows estimations to be made of the amount of time and energy invested in the production of an artefact, the level of departure of the observed form from its original form, the amount of material likely to have been created as a product of the process, how much reduction potential remains in an artefact, the position in the sequence at which changes in manufacturing strategies took place or new fracture features appeared, as well as the effects of varying reduction intensity on artefact morphology.

At a higher interpretive level, measures of reduction can be seen as critical to the testing of behavioural models that hypothesize the place of stone artefacts in broader systems of time budgeting, mobility and land use. Consequently, measures of reduction have come to be associated, at least implicitly, with discussions of risk, cost, and efficiency in past technological systems (Bleed, 2001). These discussions build on the assumption that the differential distribution of sequential steps and stages through space and time will reflect aspects of planning, land use, ecology and settlement and subsistence patterns effecting people's daily lives (Nelson, 1991, Kuhn, 1995). Measures of reduction are consequently fast becoming a central component of lithic analyses that seek to answer questions about past land use, mobility and processes of artifact manufacture and discard, as this volume demonstrates.

A common useage of measures of reduction today is the construction of sequence models. Sequence models are theoretical constructs that attempt to time-order phenomena by positioning them at points along a temporal continuum. In lithic studies, sequence models are typically used to determine the ordering of technical actions and outcomes involved in the reduction of stone materials. Models of this sort often use measures of reduction intensity to track changes in artefact morphology throughout the reduction process, enabling the identification of common forms, or the amount of variation found at different points along the reduction continuum. Sequence models have proved particularly useful in understanding and graphically depicting the various steps and transformations that characterize a wide range of lithic reduction strategies across space and time.

As Bleed (2001) and Dibble (1995) have pointed out, however, not all reduction oriented studies share the same research goals or even the same philosophical underpinning. Some approaches, they argue, promote a normative view of reduction that focuses on revealing the predetermined stages prehistoric artisans went through to produce specific 'end-products' in accordance with a mental template. Others seek to draw out the contingent nature of technological responses to changing options and circumstances by examining the nature and frequency of artefacts at different stages of reduction across space and time. Others still have used sequence models to expose the arbitrariness of typological divisions by demonstrating the existence of underlying morphological continuums.

Bleed (2001) sees different approaches to sequence modelling as falling into one of two categories, which he calls 'teological' and 'evolutionary'. Teleological models treat sequences as "a set of internally determined actions that follow one from another and lead to a predetermined goal", whereas evolutionary models describe results that are produced "by selected interaction between conditions and variables" (Bleed 2001:121). Teleological models should therefore attempt to express the variation within a particular reduction system as much as the central tendency. Thus, while reduction sequences provide a useful means of ordering different assemblage components into various degrees of reduction, there is no reason to link this depiction to normative modes of behaviour or the existence of 'mental templates' for stone artefact production.

Ultimately, once reduction sequences are well understood in a number of regions for a number of time-periods, it is anticipated that significant variations will emerge in the way people have approached the same problem of making and mending stone tools, and this is already quite apparent from only a handful of studies comparing Middle-Paleolithic scraper reduction sequences across Europe and the Middle-East (Close 1991; Dibble 1995; Gordon 1993). In fact, if charting historical and stylistic differences between regions is a focus of investigation, then a reduction approach offers great potential to explore these issues, by providing a firm basis on which to compare similarity and difference in subtle aspects of material selection, design and execution.

Studies of reduction may also cast new light on the issue of typological richness (or even cognitive complexity) by determining whether more or less types may simply represent more or less divisions of a single continuum, the emergence of new sequences, or the convergence or divergence of multiple sequences to create novel forms.

Some will argue that use-wear or residue studies are the appropriate test of reduction sequence models, as they may determine whether each stage is 'real' in the sense of having a discrete function. Alternatively, it might be argued that reduction sequences tell us little if the production of each type is 'staged' (though theoretically linked in a chain of continuing reduction), and was thus created as a discrete 'end product' to be kept in its current form for some time, either for functional reasons or as a

matter of cultural convention or aesthetic preference, before proceeding immediately to the next stage, and so on. Thus, regardless of whether a type 'could' or 'would' have been transformed into another form had it not been lost or discarded, its current form was nevertheless a 'finished' form.

Although one or both of these points could be true in certain cases, Dibble (1995) has pointed out that they need not undermine the goals or validity of a reduction sequence approach, nor would they necessarily result in incompatible interpretations. Such interpretations could easily run side by side with, or could be overlaid on top of a reduction sequence model that aims initially to describe only the nature and variability of the transformation process. To arrange artefacts in a continuum based on the amount of material removed, and to order them into likely stages through which each type may progress, does not deny the existence of ethno-taxonomies or that people may have ascribed different meanings or levels of significance to different artifacts or stages in the process. Equally, it does not rule out using artefacts in different ways as their mechanical suitability changes and they become suited to new functions. Indications that certain types were used in specific ways or in certain contexts may indeed help determine whether this is so or not.

Alternatively, use-wear analysis may instead demonstrate that a range of forms could be employed in a range of tasks (as several studies now show), and therefore, that morphology may better reflect certain design requirements, such as suitability for hafting or potential for extended resharpening, rather than a simple form-function relationship. Different viewpoints on the determinants of assemblage variability may therefore coexist, and the interpretive spin will depend on the theoretical standpoint of individual archaeologists. Reduction oriented approaches provide an analytical tool that may be grafted to many theoretical frameworks.

An example of this is to be found in two contrasting approaches that have largely emerged along continental lines, and that place differing emphasis on cultural choice and intentionality as explanatory mechanisms accounting for differences in the overall system of raw material procurement, reduction, use and discard. For example the châine opératoire approach now common in Europe (Bar-Yosef and Meignen 1992; Boëda 1988, 1993; Boëda *et al*. 1990; Karlin *et al.* 1991; Boëda and Pelegrin 1983; Geneste 1988, 1989, 1990; Meignen 1988; Pelegrin *et al.* 1988; Perlès 1987; Perlès and Binder 1990; Tixier *et al.* 1980; Turq 1988, 1992), and largely based on the social anthropology of Leroi-Góurhan (1964) and Lemonnier (1983, 1993), views the study of reduction behaviour and the 'technical choices' involved in knapping and tool use, as a profitable means of determining the goals, social context and intended end products of prehistoric artisans, as well as a way of exploring the phenomenological world of the maker.

Others (Dibble 1995; Neeley and Barton 1994; Gordon 1993; Hiscock 1994b, 1996b, 1998, 2000, In Press), and particularly those that are influenced by processual and evolutionary schools of thought, prefer to see stone artefacts in the archaeological record as either broken, lost or exhausted implements, reflecting as much the undesirable characteristics that led to their discard as the intentional features of design and artifice – in other words, the by-products of their manufacture and maintenance (Dibble 1995; Bleed 2001). From this standpoint, the reduction sequence is usually portrayed as a profitable way of determining the ecological context of production and discard, with priority given to the economic relations of demand and supply, cost and benefit, in explanations of assemblage variability. Individual creativity, selection and choice are recognized, but are usually portrayed as sources of variation - the persistence of which is dependant on the operation of selection and undirected evolution (Bamforth and Bleed 1997). Explanations of change from this perspective generally focus on longer time-scales and recognize the historically contingent nature of solutions that arise to meet various problems (Barton 1997; Bleed 1997; Bamforth and Bleed 1997; Hiscock In Press; Schott 1997).

Generally speaking, neither perspective denies that aspects held central to the other standpoint are important determinants of variation. Rather, various theoretical and methodological differences arise from choices about whether to place emphasis on either social or ecological/economic relations, but naturally views part-way between these two extremes can also be found (e.g. Sellet 1993).

The explanation for changes in stone technology and intensity of reduction in this volume tend more toward the latter approach, emphasizing the operation of ecological and economic processes in operation over many millennia. However, most authors acknowledge that these changes could be interpreted in other ways. Whatever the interpretive spin, analysis of reduction allows important dimensions of stone artefact procurement, manufacture, transport and discard to be measured, compared and contrasted.

One way to review the various uses to which studies of reduction can be put is to examine the wide range of case studies presented in this volume.

Themes in this Volume

The most ubiquotous of the themes in this volume is the concern for quantifying the amount of retouch artefacts have received as well as the effects of differential reduction on artefact form. This emphasis on appropriate procedures for measuring retouch results in the compilation of a new and exciting range of techniques with which to depict the manufacturing process and its various products. In Chapter 2, for example, Hiscock and Clarkson re-examine various measures of reduction

intensity that have been proposed over the last 20 years or so. The performance of a number of measures is evaluated over the course of a reduction experiment that was designed to determine which is best suited to measuring reduction intensity on flakes that are unifacially retouched along one margin. They compare the performance of each index to the actual percentage of the original weight lost from flakes as retouching continues. Their experiment reveals some surprising results that do not bode well for a number of widely publicised retouch measures, while also revealing that a common critique of Kuhn's geometric index of reduction appears largely unfounded. Hiscock and Clarkson's study prefaces many of the case studies that follow by demonstrating the success of the retouch measure most commonly employed throughout this volume.

Building on this experimental work, Clarkson (Chapter 3) employs the recommended reduction index to explore the effects of retouch intensity on scrapers from one region of northern Australia. He finds that much of the morphological variation found in these artefacts is a product of varying levels of reduction. The study also considers how well these artifacts fit into traditional typological classes once they are ordered into different levels of reduction, and whether in fact these classes form discrete and coherent categories at all. In so doing, Clarkson introduces the second theme pervading this volume - the issue of classification – in which studies of reduction are used to challenge exisiting typologies, demonstrate continuums and explore the boundaries between various subsets of retouched assemblages. Classification is one of the most germane and arguably most important activities undertaken by archaeologists, in that it shapes the way we think about phenomena, the way we partition it into analytical units, and thus the way our data are collected and communicated. Indeed, few issues have been so persistently debated in archaeology as the way classificatory systems should be constructed and their metaphysical basis, and the studies in this volume make a valuable contribution by demonstrating the mutability of artifact form and the existence of morphological continuums. Clarkson's analysis of scraper reduction continuums, for instance, adds to a growing number of studies that call into question the value of traditional typologies as useful descriptions of artefact variability.

Lamb (Chapter 4) also employs measures of reduction to explore issues of artefact form and classification. She uses measures of retouch, size and implement form to examine whether the manufacture of backed artefacts was the sole focus of reduction activities at the South Molle Island Quarry or whether they represent a subset of a broader range of manufacturing activitites undertaken at the quarry. As backed artifacts are one of the most frequently documented retouched artefact forms found in eastern Australia, regional studies such as this enable better definition of their classificatory boundaries and contribute much to our understanding of this widespread technological tradition. Lamb's methods could be used to great effect in exploring the nature of backed artefact production in other assemblages in Australia and elsewhere.

Hiscock and Attenbrow (Chapter 5) continue with the theme of reduction continuums by looking at the scraper reduction at Capertee 3 in the Sydney Basin. Rather than explore issues of classification, however, their research highlights the eternal contradiction between the traditional presumption of strong form-function relationships in stone tool types on the one hand, and the progressive modification of tool edges and changing artifact suitability on the other. Though less pervasive in archaeological thinking until recently, this notion of dynamic change and thresholds in tool suitability has formed the flip-side of functional arguments about stone tools for at least 100 years. Hiscock and Attenbrow masterfully expose naïve and yet alarmingly pervasive ideas about artefact design and stone tool function, and urge us to consider more sophisticated models of tool maintenance, optimality and in future formulations.

The importance of the gradual modification, addition and obliteration of fracture features over the reduction sequence were issues raised by Hiscock and Attenbrow. Macgregor continues with this line of enquiry by examining the potential of abrupt terminations to Inhibit further reduction of a nucleus. His experimental study identifies some of the causes of abrupt terminations as well as the conditions under which they are likely to be repeated, thereby hastening the discard of the nucleus, or overcome, thereby allowing reduction to continue. Macgregor introduces us to the valuable concept of 'reduction potential', which considers both core geometry and reduction technique in assessing the potential of a nucleus to be reduced to differing degress. He proposes several strategies that knappers could use to overcome the problems caused by abrupt terminations, and suggests that these strategies will likely be employed to differing degrees depending on the costs involved in raw material procurement. Macgregor is therefore able to lead us from a rigorous study of controlled fracture processes into a discussion of the organisational benefits accruing from employing certain reduction strategies in particular environmental and behavioural contexts, making this a valuable example of the potential for experimental studies to generate new data and hypotheses of direct relevance in understanding past human behaviour.

Shiner *et al*'s study (Chapter 7) picks up on another of the themes central to this volume - the potential of studies of reduction to reveal valuable information about the nature of past landuse practices such as mobility, occupational duration and intensity. In an analysis of two open sites and a rockshelter sequence of comparable age, they examine the complex interplay of raw material transport, occupational duration and age-span as reflected in reduction intensity and assemblage composition. Their analysis reveals complex patterns that undermine simple

interpretations of assemblage variability that also challenge the common notion that rich rockshelter assemblages must represent very different technological activities and occupational intensities to those seen in open sites.

Law (Chapter 8), also armed with several measures of measures of reduction intensity, continues the examination of settlement and subistence behaviour by exploring changing group mobility and landuse over the course of the Holocene at Purritjarra in Central Australia. Law uses his data on changing changing levels of reduction to assess changes in technological provisioning that might be equated with the varying frequency and predictability of residential moves. This novel approach allows Law to weigh up competing models of Holocene arid zone settlement, arriving at a new interpretation of Holocene settlement at Purritjarra to that which had previously been proposed.

Mackay (Chapter 9), on the other hand, while also concerned with mobility and landuse, is confronted with the absence of formal types in assemblages located on and around Ngarrabullgan, a table-top mountain on Cape York Peninsula. His search for a new analytical approach leads him to explore the power of a purely attribute-based analysis of assemblages from surface sites and excavated rockshelter deposits spanning the last 5,500 years. This study is an elegant example of the way in which artefacts traditionally designated 'debitage' and usually left unanalyzed can be engaged to reveal detailed information about past settlement and subsistence practices. This chapter offers a valuable example to archaeologists struggling to incorporate whole assemblages into their research rather than limiting their analysis to the tiny subset that is constituted by formal implement types.

The final paper in this volume draws together the several themes that unite this volume and assesses the value and future directions of the reduction thesis and its discontents. It also compares and contrasts the perspective and ideas taken up by those working in Australia with research that is currently being conducted elsewhere in the world. The final chapter is not only an overview of the volume, but also a substantive and insightful contribution to this exciting branch of lithics research.

Conclusion

This volume represents a compilation of papers of a kind that have rarely been assembled in one place before. It is one of the first of its kind to explore stone artefact reduction as a central and unifying theme, and to explore its many implications and applications within the realms of lithic classification, tool function and settlement and subsistence studies. We hope that readers find the ideas and approaches contained whithin this volume stimulating and worth pursuing in their own research areas.

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